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USE OF RADIATION AND CHEMICAL MUTAGENS IN THE PRODUCTION OF MUTATIONS
IN A CROP OF RELEVANT INTEREST TO MEDITERRANEAN AGRICULTURE, DURUM WHEAT.

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1. INTRODUCTION

Durum wheat, the raw material for macaroni production, is essentially a crop of semi-arid climates; it is grown mostly in Southern Europe, North America, North Africa, Near East, URSS and Argentina. Yield of durum is substantially less than that of bread wheat. Production of durum wheat in the Mediterranean countries, for which data are available, (Table 1), covers nearly 80 per cent of world production. In Italy, which is the largest producer in Western Europe, durum yields have declined every year from 1957 to 1960, whereas acreage was virtually unchanged.

In view of the economic importance of durum wheat in Italy, and in the Mediterranean area generally, a program on experimental mutagenesis in this crop started in 1956, for both fundamental genetic research and breeding of improved lines. So far, mutation induction by seed treatment has been carried out in the varieties Cappelli, Aziziah, Russello, Grifoni and Garigliano; the mutagens used were X-rays, thermal neutrons, fast neutrons, ethyl methane sulphonate (EMS) and diethyl sulphate (DS). The total number of treated seeds amounted to 65,000. Among the five varieties employed in our experiments, Cappelli covers more than 50 per cent of the acreage of durum wheat in Italy, owing to flour quality and relatively good yield. Therefore, our efforts have been concentrated on this variety.

2. TYPES OF INDUCED MUTATIONS

a) Chlorophyll mutations.

Scoring of chlorophyll mutations in the M_2 generation (progeny of plants grown from treated seeds) took place in the greenhouse; a total number of 20,200 spikes, belonging to 5,902 M_1 plants, were analyzed. The following types of mutations were found: albina (white), xantha (yellow), xanthalba (leaf tip yellow, base white), chloroalbina (tip yellow-greenish, base white), viridoalbina (tip light green, base white), striata (white or yellow longitudinal stripes), tigrina (brown or yellow transverse stripes), chlorina (yellow green), viridis (light green). The relative frequencies of the various types of chlorophyll mutations

(mutation spectra) induced by EMS and DS are significantly different from those induced by radiations. Within the three types of radiations used, differences in mutation spectra are not significant or are at the limit of significance.

Figure I shows the frequencies of chlorophyll mutations per spike progeny induced in durum wheat by the different mutagenic treatments applied. As shown by figure I, the mutation frequencies rise up to more than 6% in some neutron irradiations; this maximum value is comparable to, and possibly higher than, that found in radiation experiments in another tetraploid wheat species, Triticum dicoccum (1,2). If the M_2 mutation frequencies are considered in relation to M_1 survival, it is observed that, at comparable survival rates, the mutation frequencies induced by thermal and fast neutrons are several times higher than those produced by X-rays (3). This result is in agreement with the well known greater biological efficiency of neutrons as compared to X-rays.

A characteristic common to the three types of ionizing radiations used is that high mutation rates are induced by doses producing a strong reduction, generally from 50 to 80%, in the mean number of M_2 seedlings per spike (in practice, average spike fertility). On the contrary, with EMS and DS, the highest mutation frequencies are observed in treatments producing only a 33 to 42% reduction in the mean number of M_2 seedlings per spike (3). This contrasting behaviour of radiations on one side and chemicals on the other is clearly shown in figure II, illustrating, for each of the five mutagens used, the frequency distribution of chlorophyll mutations in mutated spikes, grouped in classes according to the number of seedlings produced by each of them (values relative to the average of controls taken = 100). It is apparent that, with chemical mutagens, spikes carrying mutations accumulate towards higher classes, while the opposite holds true for ionizing radiations. More precisely, in chemically treated material, the highest relative percentages of mutated spikes are found in the classes from 60-80 to 100-120; with radiations, a similar situation occurs in the classes from 20-40 to 60-80.

Another conspicuous difference in action between radiations and chemical mutagens lies in the size of mutated sectors in M_1 spikes as revealed by M_2 segregation ratios. Taking into account all radiation experiments, the mean segregation ratio was 15.9% (range 11.6-19.7%). In contrast to radiations, the segregation ratios found in chemically treated material ranged from 3.9 to 14.9% (mean 11.8%). This situation seems to be best explained by a more severe elimination of cells in the spike primordia of seeds following irradiation. In spite of the clear reduction in size of mutated sectors in M_1 spikes from chemically treated seeds, a comparable average number of mutants per mutated spike is observed with both chemical mutagens and radiations. This result, to be ascribed to the compensating effect of the better M_1 spike fertility in chemical mutagen treatments, may be of significance for the plant breeder also (3).

b) Viable mutations.

In M_2 and following generations in durum wheat, viable mutations affecting several physiological and prominent phenotypic characters have been isolated. At present, a total of 268 mutations, each of which derived from a single M_1 plant, is available at our Laboratory. These mutations involve either single or several characters (complex phenotypes) manifesting themselves in the various stages of the vegetative cycle (Table 2). Among the mutations listed, two appear to be of evolutionary interest, namely:

- i) "vavilovoid", characterized by an increased number of nodes and strong elongation of the internodes in the rachilla, leading to a pseudo-branched spike. This character, resembling the naturally occurring pseudo-branched spike of the hexaploid Triticum vavilovii Jakub, behaves as a simple recessive;
- ii) "supernumerary spikelets", showing 3 to 7 spikelets on each rachis node instead of one, as normally in Triticum. Also this character behaves as a simple recessive.

The whole of the mutations available is at present being made the object of genetic and cytogenetic studies. Since a large portion of the induced mutations in durum wheat are phenotypically similar to the naturally occurring ones, special attention is deserved to the inheritance of the induced changes. 12 different types of viable mutations analyzed so far have all shown a monogenic type of inheritance (recessive).

Analysis at meiosis of mutants and of their F_1 crosses to the mother line has demonstrated the occurrence, in 25 out of 50 mutants studied, of reciprocal translocations. This indicates that, in durum wheat, induced mutations often occur in association with chromosome structural changes. It is expected that reciprocal translocations, of so common an occurrence in durum wheat, might greatly help in the analysis of the genetic structure of this species.

3. AGRONOMIC EVALUATION OF THE MUTANT LINES

Considering the requirements for the improvement of Italian varieties of durum wheat, several induced mutations (short straw, solid stem, higher lodging resistance, increased spike and spikelet fertility) seem to be very promising.

Large-scale field trials for an agronomic evaluation of some of the induced mutants have been greatly facilitated by the establishment, in 1960, of a Research group on durum wheat, sponsored by the Italian National Research Council. The Research group includes, besides our Laboratory, the following Institutes: Institute of Genetics of the University, Pisa (Director: Prof. F. D'Amato), Institute of Cereal Genetics of the Ministry of Agriculture (Director: Prof. U. De Cillis), Institute of Plant Pathology of the University, Bari (Director: Prof. A. Ciccarone), Institute of Agronomy of the University, Bari (Director: Prof. L. Cavazza) and Institute of Agronomy of the University, Sassari (Director: Prof. R. Barbieri).

In the seasons 1960-1961 and 1961-1962, field trials have been carried out in 4 Stations in Southern and Central Italy and in Sardinia, namely: Bari, Foggia, Roma and Cagliari. Data on the performance of some of the mutants in the four localities are shown in Figure III. It is seen that the mutant lines M26, M34, M38, M62 manifested a good performance in most trials, reaching in some of them yields significantly higher than those of the mother line "Cappelli" (* $P = 0,05$; ** $P = 0,01$). A similar behaviour has been demonstrated in the lines M124 and M177, so far tested at Rome and Bari only.

A good yielding ability was observed also in other mutants, often associated with good quality (yellow berries absent), increased 1000-kernel weight, short straw and increased lodging resistance. The phytopathological analysis of mutants of agronomic interest has given an indication of the induction of resistance to mildew and Septoria in some of them.

"Cappelli", a variety with a satisfactory lodging resistance, becomes very lodging sensitive in fertile soils and, particularly so, in consequence of nitrogen manuring. To verify if some mutants had a higher lodging resistance in soils with high nitrogen content, an experiment with 8 short straw mutants was carried out. The behaviour of the control and of 3 of those mutants at different nitrogen levels is shown in Fig. IV. It is apparent that some mutants can use nitrogen fertilization better than the control (see M115 and M107), probably because of their higher lodging resistance.

In spite of the favourable prospects on the direct utilization of induced mutations, crosses aiming at the transfer into single lines of some of the best characteristics obtained by mutation are being carried out.

REFERENCES

- 1) MAC KEY J. (1954) Mutability at diploid and polyploid level. Proc. 9th Int. Congr. Genetics, Suppl. Caryologia 6: 697-698.
- 2) NATARAJAN A.T., SIKKA S.M., SWAMINATHAN M.S. (1958) Polyploidy, radiosensitivity and mutation frequency in wheats. Proc. 2nd U.N. Intern. Conf. Peac. Uses Atom. En. Geneva, vol. 27: 321-331.
- 3) D'AMATO F., SCARASCIA G.T., MONTI L.M. and BOZZINI A. Types and frequencies of chlorophyll mutations in durum wheat induced by radiations and chemicals. Radiation Botany (in press).
- 4) SCARASCIA G.T., D'AMATO F. and BOZZINI A. (1961) Mutazioni morfologiche indotte dalle radiazioni in grano duro "Cappelli". Atti A.G.I. vol. 6: 371-380.

TABLE 1

DURUM WHEAT AREA, PRODUCTION AND YIELD (AVERAGE 1957-1961) IN SOME MEDITERRANEAN COUNTRIES
(Data from FAO CCP/Grains/62/12, 14 June 1962).

	AREA (Thousand Hectares)	PRODUCTION (Thousand Metric Tons)	YIELD (Quintals per Hectare)
ITALY	1384	1527	11,0
SPAIN	450	415	9,2
PORTUGAL	180	124	6,9
FRANCE	50	60	12,0
ALGERIA	1347	906	6,7
TUNISIA	1091	350	3,2
MOROCCO	1016	682	6,7
TURKEY	1700	1663	9,6
SYRIA	1448	769	5,3
IRAQ	785	385	5,0
TOTAL	9451	6891	7,3

Table 2. - Types and number of viable mutations for individual and complex characters in durum wheat induced by radiations and chemicals.

MUTATIONS	X	N	C(★)	Total
Tigrina	2	21	11	34
Viridis	-	17	5	22
Chlorina	2	10	7	19
Virescens	3	13	8	24
Dark green	1	-	-	1
Prostrate tillering	1	2	-	3
Short leaf	1	-	-	1
Anthocyanic leaf	2	14	6	22
Narrow leaf	-	1	-	1
Solid stem	1	-	-	1
Solid stem, lax ear	1	-	-	1
Waxless	4	8	-	12
Waxless (spike only)	-	-	1	1
Short straw	-	31	-	31
Compact ear	1	4	-	5
Squarehead	-	1	-	1
Tetragonal ear	2	-	-	2
Lax ear	-	11	-	11
Red brown spotted awn and glume	1	4	1	6
Awned glume	1	-	-	1
Falcate caryopsis	-	1	-	1
Shrunken endosperm	1	-	-	1
Dwarf, late	-	2	1	3
Dwarf, twisted culm and leaf	1	1	-	2
Vavilovoid	2	5	1	8
Brachytic, compact ear	1	3	-	4
Brachytic, twisted ear	1	2	-	3
Supernumerary spikelets	-	1	1	2
Short straw,narrow leaf,slender ear,awned glume	4	5	-	9
Short straw,plicate leaf,awned glume	-	1	-	1
Short straw,short leaf,compact ear	1	-	-	1
Short straw, lax ear, attenuated glume	-	3	-	3
Short straw, narrow leaf, slender culm	-	2	-	2
Short straw, narrow leaf, compact ear	-	1	-	1
Short straw, compact ear	-	1	-	1
Short straw, narrow leaf, lax ear	-	1	-	1
Short straw, lax ear, awned glume	-	8	-	8
Short straw, compact ear, awned glume	1	5	-	6
Short straw, lax ear	-	4	-	4
Short straw, awned glume	-	3	-	3
Short straw,compact ear,attenuated caryopsis	-	1	-	1
Tall, small glume and caryopsis	-	1	-	1
Small ear and caryopsis	-	1	-	1
Narrow leaf, short glume, small caryopsis	-	1	-	1
Compact ear, awned glume	-	1	-	1
Total mutations	35	191	42	268

(★). X = X rays; N = Neutrons; C = Chemicals

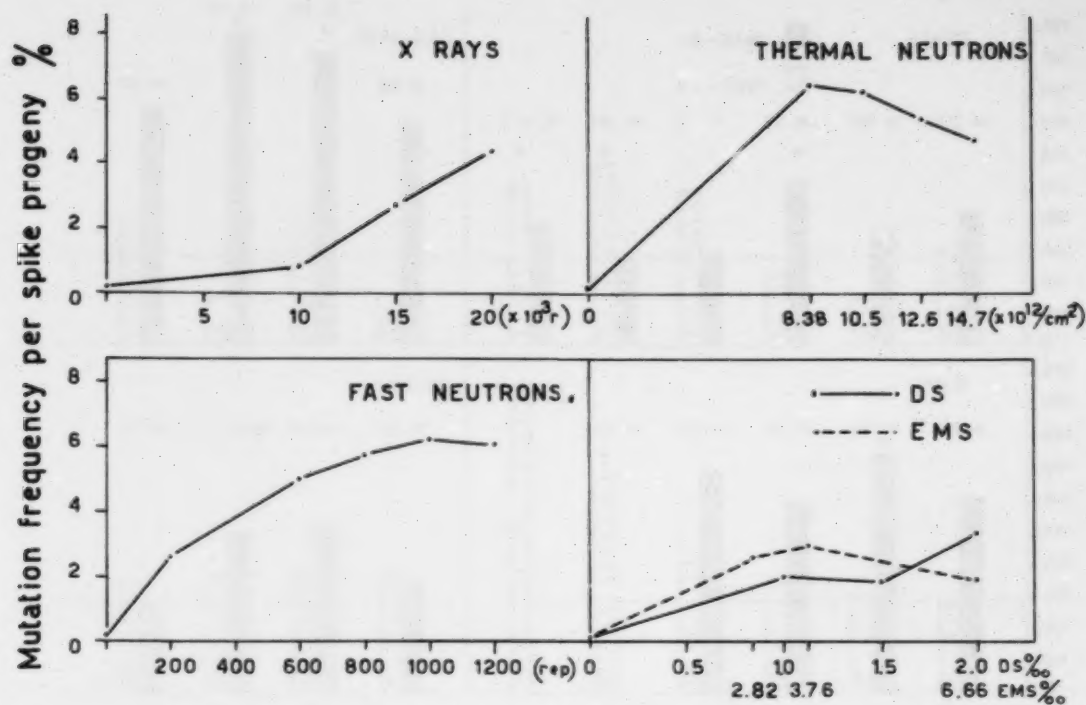


Fig. I - Frequency of chlorophyll mutations induced in durum wheat by X rays, thermal neutrons, fast neutrons, diethylsulfate (DS), and ethylmethanesulfonate (EMS).

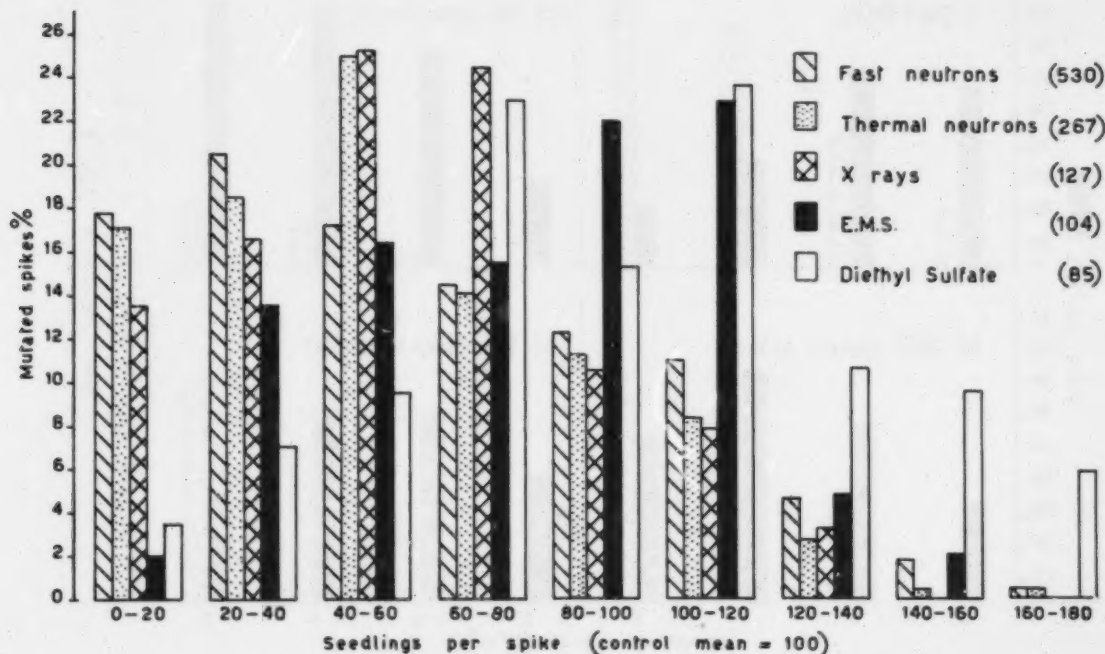


Fig. II - Frequency distribution of mutated spikes grouped according to number of seedlings per spike (in brackets total no. of mutated spikes observed).

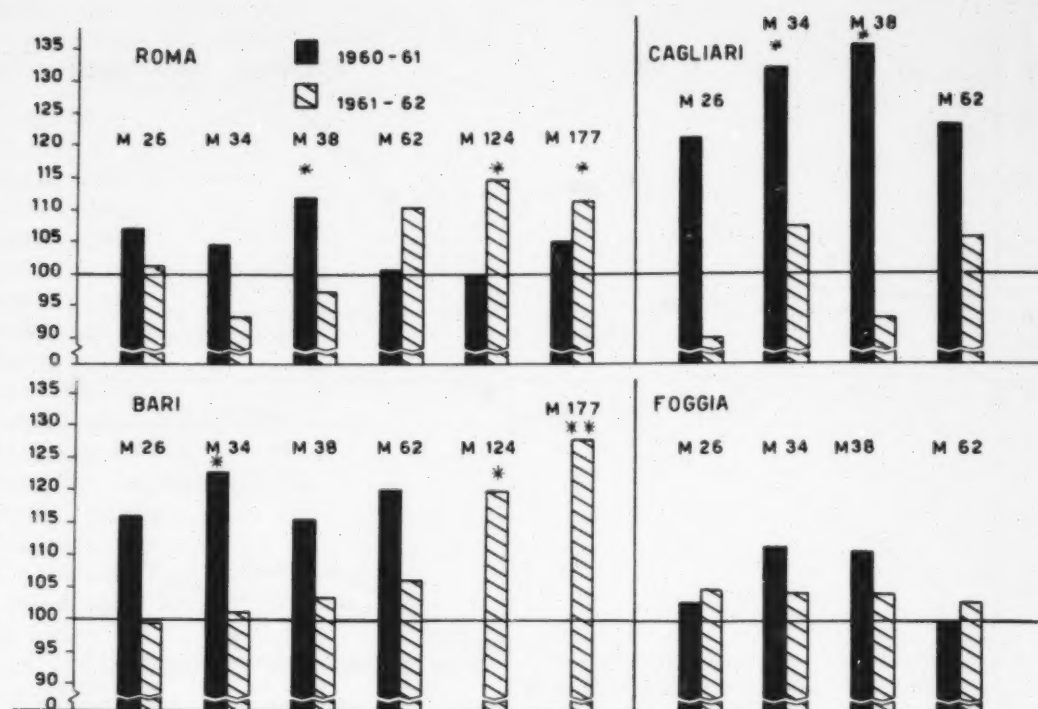


Fig. III - Yield of durum wheat mutants (in % of control) in different trials.

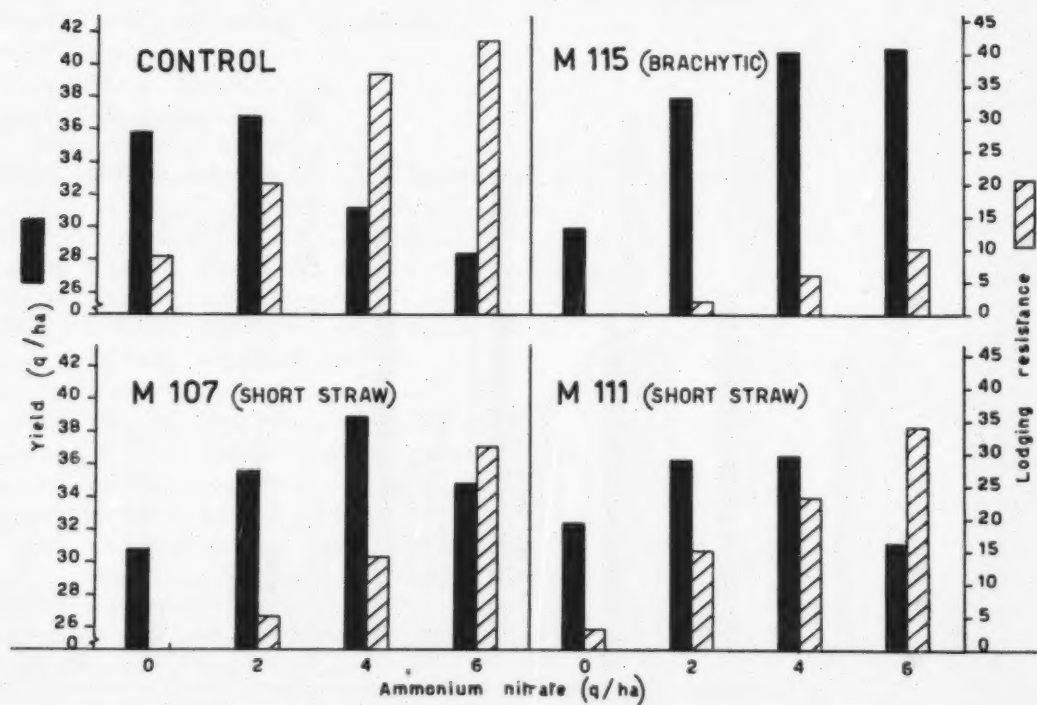


Fig. IV - Yield and lodging resistance in 3 durum wheat mutants grown at different nitrogen levels (0=no lodging; 45=maximum lodging).

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